Engineering and Environmental Sciences Division
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BIOMEDICAL APPLICATIONS OF NASA SCIENCE AND TECHNOLOGY

Contract No. NASW-1950
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Quarterly Progress Report 1
15 June 1969 to 14 September 1969

Prepared for

National Aeronautics and Space Administration
Technology Utilization Division
Washington, D. C. 20546

PREFACE

This report covers the 15 June 1969 to 14 September 1969 activities of the NASA Biomedical Application Team at the Research Triangle Institute. These activities were performed in accomplishing Tasks A through F, Statement of Work, NASA Contract No. NASW-1950. Accomplishment of Task G, Supplementary Efforts, is reported separately. This work was performed in the Engineering and Environmental Sciences Division of the Research Triangle Institute under the technical direction of Dr. James N. Brown, Jr. Full-time members of the team and other RTI staff members who participated in the project are Dr. F. T. Wooten, Mr. Ernest Harrison, and Mrs. Sandra K. Burt. Assistance from other members of the RTI staff is obtained on an as-needed basis.

Medical consultants who contributed significantly to the project are Dr. E. A. Johnson, Professor of Cardiac Pharmacology, Duke University Medical Center, Durham, North Carolina and Dr. G. S. Malindzak, Jr., Associate Professor of Physiology, Wake Forest University, Bowman Gray School of Medicine, Winston-Salem, North Carolina.

ABSTRACT

This report presents the results of the activities of the NASA Biomedical Application Team at the Research Triangle Institute. This experimental program in technology transfer was supported by NASA Contract No. NASW-1950 for the reporting period 15 June 1969 to 14 September 1969. The RTI Biomedical Application Team is a multidisciplinary team of scientists and engineers acting as an information and technology interface between NASA and individuals, institutions, and agencies involved in biomedical research and clinical medicine. At present, the RTI Biomedical Application Team is staffed by: J. N. Brown, Electrical Engineer; F. T. Wooten, Electrical Engineer; Ernest Harrison, Physicist and Materials Scientist; and Sandra Burt, Information Specialist. Additionally, the team draws upon the capability of other members of the RTI staff as needed.

Eight medical organizations are presently participating in the RTI Biomedical Application Team program: Duke University Medical Center, Durham, North Carolina; the Medical School of the University of North Carolina, Chapel Hill, North Carolina; the University of North Carolina Dental School and Dental Research Center, Chapel Hill, North Carolina; the Bowman Gray School of Medicine, Winston-Salem, North Carolina; the North Carolina State University, Raleigh, North Carolina; the Veterans Administration Hospital, Durham, North Carolina; the Institute of Rehabilitation Medicine of New York University Medical Center, New York, New York; and the National Cancer Institute, Bethesda, Maryland.

The accomplishments of the Research Triangle Institute Biomedical Application Team during the reporting quarter are as follows: The team has identified 19 new problems for investigation, accomplished four transfers of technology, closed seven old problems, and on 14 September 1969, had a total of 92 problems under active investigation.

Significant transfers of technology include a new material for hip joint prosthesis developed from low friction space bearings, as well as

a cardiotachometer designed at NASA's Lewis Research Center.

New conclusions drawn regarding selection criteria for consultants will allow more rapid identification of consultants at user institutions.

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1.0 INTRODUCTION AND SUMMARY

The Technology Utilization Division of the National Aeronautics and Space Administration is experiencing success in transferring the scientific and technological results of the nation's aerospace activities to applications in nonaerospace related national programs. The transfer of science and technology to the biomedical field and the study of the process by which this transfer occurs is one of the major endeavors in NASA's Technology Utilization Program. Systematic problems are encountered in transferring technology to problems and needs existing in the biomedical field. These problems are a result of differences in languages, methodologies, and environments encountered in the physical, engineering, and life sciences.

In order to create a mechanism for and to facilitate the transfer of scientific and technological information to clinicians and medical investigators, the National Aeronautics and Space Administration is presently sponsoring three multidisciplinary Biomedical Application Teams. These three teams are located at the Research Triangle Institute, Research Triangle Park, North Carolina; the Midwest Research Institute, St. Louis, Missouri; and the Southwest Research Institute, San Antonio, Texas. These three application teams closely coordinate their activities to avoid duplication of effort and to enhance investigation of the technology transfer process.

The objectives of NASA's Biomedical Application Team Program are both experimental and operational. The experimental phase of the program is the study of the technology transfer process and the development of a systematic approach to transferring aerospace technology to applications in medicine and biomedical research. The operational phase of the program is the transfer of specific items of aerospace technology to the biomedical field and the generation of a data base for further study of the transfer process.

The methodology employed by the Biomedical Application Team can be subdivided into four major phases of action: identification and specification of the problem, identification of relevant information

or technology, evaluation of potentially applicable information or technology, and documentation of specific applications or technology transfers and the manner in which these technology transfers were accomplished. The methodology is outlined in a flow chart shown in the figure on page 5.

The first phase of the transfer process, identification and specification of the problem, is the initiation of discussion between members of the team and medical investigators at participating medical institutions. In these meetings, team members obtain an understanding of the problems and requirements posed by the medical investigators and of the way these problems are affecting the progress of medical research or hindering patient treatment and care. Following these discussions and preliminary literature research, the team identifies specific technology-related problems and prepares biomedical problem abstracts on each specific problem. These biomedical problem abstracts describe a single problem in a concise manner using functional and nondisciplinary terminology. The also describe the significance of the problem and the benefits which would likely be realized if a solution can be found.

The second phase in the transfer process, the identification of relevant information and technology, involves two approaches to obtaining information. The first approach is a computerized information search of NASA's aerospace information bank. This information bank consists of the entries in the Scientific and Technical Aerospace Reports and the International Aerospace Abstracts. These computer information searches are performed collaboratively by members of the application team and applications engineers at NASA Regional Dissemination Centers, such as the North Carolina Science and Technology Research Center located in the Research Triangle Park, North Carolina. In the second approach, biomedical problem statements are desseminated through the Technology Utilization Division of NASA to the NASA Research Centers to solicit, from individual engineers and scientists, assistance in solving problems.

The third step in the transfer process involves an evaluation of information which appears to be relevant to the solution for a specific

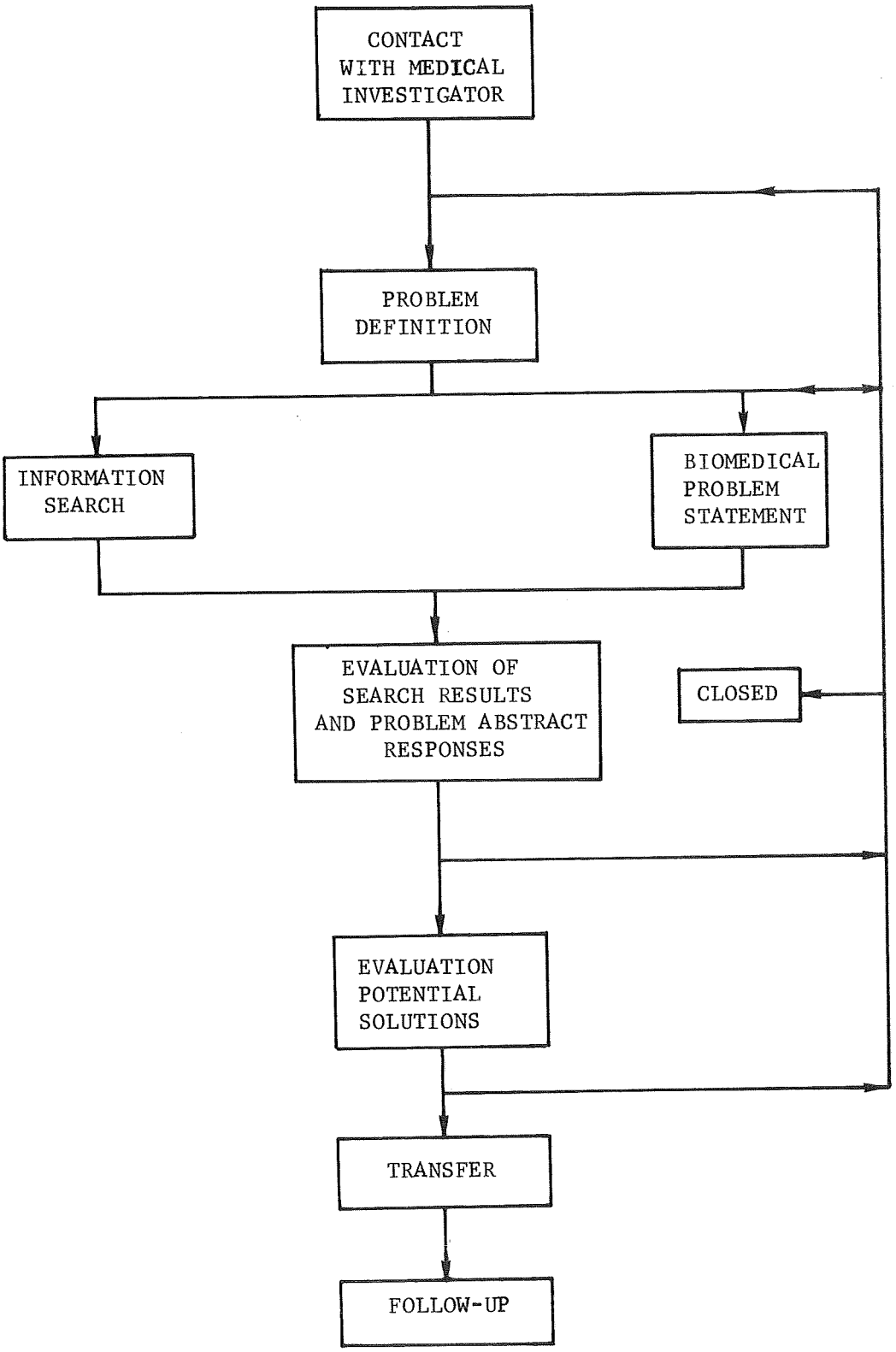
problem. This evaluation is performed both by members of the team as well as the problem originator. If information is identified which appears to offer a solution to a specific problem, the team encourages and, to a certain extent, assists the investigator in applying this information in his research project.

The final phase of activity involves the complete and detailed documentation of specific problems, the technology of information which was applied, and a description of how the relevant information was identified. Documentation is required both for further study of the transfer process as well as for wide dissemination of the information throughout the medical community.

Eight medical schools and institutions are presently participating in the RTI Biomedical Application Team program. The interface with each institution depends on the particular circumstances but, in each case, the goal is to provide minimum interface difficulties. For example, at Duke University Medical Center, Durham, N. C., at Wake Forest University Bowman Gray School of Medicine, Winston-Salem, N. C., and at the Institute of Rehabilitation Medicine of New York University, New York, N. Y., the team maintains a consultant who is a physiologist or physician and who is a member of the university faculty. These consultants provide valuable assistance in identifying and defining new problems. At the Veterans Administration Hospital, Durham, N. C., the medical staff in general holds joint appointments at Duke University Medical Center so that a separate team consultant is not required at the VA Hospital. No consultant is maintained at the University of North Carolina Medical School, Chapel Hill, N. C., and the University of North Carolina Dental School and Dental Research Center, Chapel Hill, N. C. At the National Cancer Institute, the consultant is a staff engineer who is intimately familiar with the research activities at NCI and, thus, provides the valuable assistance useful in identifying and defining problems. At North Carolina State University, Raleigh, N. C., no consultant is required because of the low number of available problems at this institution and because team members have a good personal knowledge of campus research activities.

Section 1.0 of this report contains a summary and introduction to the report. Section 2.0 presents a discussion of the transfers of technology made by the Research Triangle Institute's Biomedical Application Team during this quarter. Section 3.0 enumerates the new problems which have been identified. Section 4.0 consists of a problem status summary, which gives briefly the current standing of the various problems. Section 5.0 presents other activities of the team while section 6.0 contains a discussion of conclusions drawn this quarter. Section 7.0 contains specific plans for the coming quarter.

Flow Chart Showing BATeam Methodology



2.0 TECHNOLOGY TRANSFERS

2.1 Introductory Information

The basic operational goal of this program is to transfer aerospace technology to the field of medicine. A transfer is defined as the utilization of aerospace-related technology for a purpose other than that for which the technology was originally developed.

The documentation of transfers contains the following information: (1) Description of Problem, (2) Description of Solution, (3) Successful Searching Method, (4) Benefits to be Derived from Transfer, and (5) Elapsed Time to Complete.

The transfers documented here represent a solution to the following problems:

Further information on any transfer can be obtained by contacting the team member listed for each transfer.

2.2 Transfer Documentation

DU-41

Electrode Vest for EKG Measurement

Dr. W. E. Hammond, Duke University Medical Center

Team Member - Dr. F. T. Wooten

Problem Acquired - January 1969
Transfer Made - June 1969
Elapsed Time - 5 months

Description of Problem

Dr. Hammond has a general interest in health-screening clinics. He is studying ways to improve the measurement techniques for such clinics. One important measurement for such clinics is the electrocardiogram (EKG). This measurement normally is made using less than ten electrodes, with the electrodes normally being attached to the body by hand. Dr. Hammond plans to use up to 150 electrodes which would consume too much time for attachment manually. In order to facilitate their placement, the researcher wants a vest implanted with electrodes. The vest should be adaptable for both sexes from ages 3 to 16 years and should cover the area from the neck to the waist. Because of the wide range of patient size, several vests will be required.

Description of Solution

A computer search, #1595, "EKG Electrodes," disclosed several articles of interest on electrodes but no information on vests. A team member then contacted a local NASA contractor, Payne and Associates, who has experience in life vest design and manufacture. The contractor designed and built a prototype inflatable vest for evaluation which is adjustable in size and can be inflated for good contact. The vest has been delivered to the researcher.

Successful Searching Method

Team knowledge of local commercial contractors.

Benefits to be Derived from Transfer

This transfer will enable the researcher to evaluate vests for EKG measurement in health-screening clinics. These clinics will provide vital information in screening large numbers of patients for health problems. The EKG measurement is vital in diagnosing heart disease which is responsible for about half the deaths in this country.

DU-56

Material for Hip Joint Prostheses

Dr. Donald E. McCollum

Duke University Medical Center

Team Member - Dr. F. Thomas Wooten

Problem Acquired - June 1969
Transfer Made - August 1969
Elapsed Time - 3 months

Description of Problem

A major crippling disease in this country is arthritis which is a disease of the joints. In severe cases, the bone deteriorates to such a degree that joint replacement is necessary to alleviate pain and joint stiffness. One common joint requiring replacement is the hip.

Hip joint replacement is accomplished by replacing the ball and socket of the bone with a ball and socket of some appropriate material. Although the ball and socket can be of different materials, they are usually made of the same material. The most commonly used material is Vitallium, a chrome-cobalt alloy, but unfortunately it has two disadvantages--excessive wear and friction. Excessive wear causes a poor fit of ball and socket and excessive friction promotes loosening of the prosthesis in the bone. Once the prosthesis becomes loose, pain and joint stiffness return. With existing materials this can occur within one year, but a lifetime of at least ten years is desired.

New materials for hip joint prosthesis are required with lower friction and wear than the presently used Vitallium. The hip joint material must have low friction and low wear at pressures of 500 psi compression. It must be compatible with the body and be capable of being bonded to the bone. The ball and socket can be of dissimilar materials if both materials meet the other requirements.

Description of Solution

The team contacted Mr. Paul Foster, Technology Utilization Officer at NASA's Lewis Research Center, who identified Mr. R. A. Johnson of Lewis Research Center as a source of information on low friction bearings. Mr.

Johnson had conducted studies on new materials for low friction bearings in space applications. One of several materials suggested by Mr. Johnson was Vespel, a new polyimide resin produced by the DuPont Company for aerospace applications. This material has a coefficient of friction that is approximately 1/3 that of Vitallium and a wear of about 1/200 that of Vitallium under proper conditions. It appears to be a significant improvement over Vitallium if it is compatible with the body.

Dr. McCollum was impressed with the potential of this material and is presently conducting tests on the biocompatibility of this material.

Successful Searching Method

Manual search and excellent cooperation of NASA field center staff.

Benefits to be Derived from Transfer

Arthritis is a major crippling disease which cannot be adequately cured with existing prosthesis. As a result of this transfer, the researcher is starting the long series of tests necessary to verify this material as a replacement for the presently unsuitable prosthesis. If these tests are successful, many people may be able to walk that otherwise would have been permanently crippled.

UNC-38

Electromyography as an Aid to Hand Rehabilitation

Miss Irene Hollis, Hand Rehabilitation Center
University of North Carolina Medical School

Team Member - Mr. Ernest Harrison, Jr.

Problem Acquired - February 1968
Transfer Made - July 1969
Elapsed Time - 17 months

Description of Problem

The Hand Rehabilitation Center of the University of North Carolina Medical School is engaged in a program of occupational and physical therapy to help in restoring the function of the hand to people who have received injuries resulting in incapacitation. Therapy is also administered to regain function in hands where surgical corrective procedures have been

accomplished.

One important aspect of therapy is the fact that it is desirable to exercise certain particular muscles in specific fashions, in order to strengthen or regain function in these muscles. Damaged muscles are frequently favored by bringing into play some other combination of muscles to produce the motions prescribed by the therapy. As a result, a method of determining if the specific muscle involved is actually being exercised is required.

In the past, the Hand Rehabilitation Center has used a simple electromyographic (EMG) device which picks up the EMG signal from the specific muscle that is being exercised. Electromyography is a general term which includes any procedure for registering the electrical activity of muscle. A simple way to detect the electrical activity or action potentials of skeletal muscle is to place small metal disks (surface electrodes) on the skin over the muscle. No electrical activity occurs over the resting muscle. During voluntary contraction, there occurs an irregular oscillation of 0.1-2 millivolts, often with a frequency of about 50 hertz. Electrical activity is an indication of voluntary or reflex contraction of the muscle. The electrical signal magnitude is approximately proportional to the tension produced by the muscle. Thus, the magnitude of the signal can be used to judge how much neuromuscular activity is being exerted by the muscle being monitored. The device, which has been used by the Hand Rehabilitation Center was damaged beyond repair, and a suitable commercial replacement could not be found. Miss Hollis, Director of Occupational Therapy at the Hand Rehabilitation Center, located an EMG training device which has been designed at the U.S. Army Medical Biomechanical Research Laboratory, Walter Reed Army Medical Center in Washington, D. C. The Biomedical Application Team was consulted to determine the possibility of fabricating a muscle training unit according to the design produced at the Walter Reed Army Medical Center.

Description of Solution

As a result of NASA Biomedical Application Team interaction with the University of North Carolina Medical School, the investigator with an

electronic equipment fabrication problem was placed in contact with a suitable fabrication source.

The Instrumentation Section of the Engineering and Environmental Sciences Division of RTI was asked by the Hand Rehabilitation Center to furnish a quotation on the cost to fabricate an EMG muscle trainer from the design developed at the Walter Reed Army Medical Center.

Successful Searching Method

This problem essentially involved the identification of a suitable supplier to fabricate the desired EMG muscle trainer. As a result of NASA-supported Biomedical Application Team activities at the University of North Carolina Medical School, this problem came to the attention of one of the team members who, in turn, pointed out to the Hand Rehabilitation Center that a fabrication capability was available at the Research Triangle Institute.

Benefits to be Derived from Transfer

Conventional EMG machines cannot be readily used in this application because of their large size, as well as their high cost. The unit discussed herein is small enough to be used in the clinic during therapy (which is the primary need) and is also inexpensive enough to be used in normal clinical practice. In use, the EMG amplifier is used as a training device to induce the patient to use a specific muscle during the therapy process. Use of the EMG device provides a direct indication as to whether or not the muscle is being used. This device will be used to provide training and therapy on 90 percent of the patients which enter the Hand Rehabilitation Center; normally, the Center treats 30 to 40 patients per month.

UNC-53

Design Information Relating to Cardiotachometer Circuitry

Mr. Stan Hutcheson, Memorial Hospital, University of North Carolina

Team Member - Mr. Ernest Harrison, Jr.

Problem Acquired - June 3, 1969
Transfer Made - July 5, 1969
Elapsed Time - 5 weeks

Description of Problem

Circuit design information and overall design parameters are needed in the design of a cardiotachometer.

The researcher is designing a cardiotachometer for use on experimental animals. Commercial units are available, but they are limited to measurement of heart rates up to 250 beats per minute. Anesthetized rats, however, exhibit heart rates in excess of 350 beats per minute. The cardiotachometer will be used to monitor heart rate and changes in heart rate of experimental animals as a result of the administration of various stimuli and drugs. The researcher is seeking specific circuit design information, as well as overall system design considerations. The team has been requested to determine if NASA has designed, built, and tested circuitry which might be of use in the design of such an instrument.

Because the cardiotachometer will be used on animals rather than humans, the equipment design must have the capabilities to measure the higher pulse rate encountered with experimental animals; i.e., a rate of 600 pulses per minute will provide adequate margin.

Description of Solution

Documentation on the NASA-developed cardiac R-wave detector developed by Vernon D. Gebben of the Lewis Research Center, Cleveland, Ohio, was used by the researcher. Information on the overall system configuration and system parameters was used by the researcher for reference and guidance purposes in selecting basic parameters and system approaches to the design of the required cardiotachometer.

Successful Searching Method

The cardiac R-wave detector was originally brought to the attention of the Biomedical Application Team by Tech Brief 68-10144. Mr. Paul Foster, Technology Utilization Officer at the Lewis Research Center, provided detailed information, including schematic diagrams, about the R-wave detector.

Benefits to be Derived from Transfer

The completed cardiotachometer will permit obtaining the heart rate of animals for a number of studies involving reaction of test animals to drugs and other stimuli.

3.0 NEW PROBLEMS

3.1 Introduction

During the preceding period, 19 new problems have been accepted by the team for investigation. Problem statements for these 19 new problems are presented below.

3.2 New Problem Descriptions

Problem Statement

Prepared for

DU-52
June 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Bonding Agents for Hip Joint Prosthesis"

Problem Description

An improved bonding method or material is required for joining bone to metal and plastic materials.

Background

A major crippling disease in this country is arthritis which is a disease of the joints. In severe cases the bone deteriorates to such a degree that joint replacement is necessary to alleviate pain and joint stiffness. One common joint requiring replacement is the hip.

Hip joint replacement is accomplished by replacing the ball and socket of the bone with a ball and socket of some appropriate material. The most commonly used material is Vitallium which is a chrome-cobalt alloy. In order to adequately bond the metal to the bone, some bonding agent is required. The material used as a bonding agent is commonly methylmethacrylate but this material is suspected of causing tumors in some cases. For that reason, only tests on experimental animals have been used to date.

A new bonding material is desired which provides adequate bonds for the prosthesis and which is compatible with human tissue.

Requirements and Constraints

A material for, or method of, bonding bone to metal or ceramics is required. This material must provide a bond lifetime of at least ten years without causing tissue reaction. Pressure on the bond is estimated to be 500 psi in shear and compression.

Problem Originator

Donald E. McCollum, M.D.
Duke University Medical Center

For more information contact

F. Thomas Wooten, Ph.D.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

A computer search of the NASA literature, #1749, "Biocompatible Plastics," has been delivered to the researcher.

Problem Statement

Prepared for

DU-53
June 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Electroencephalogram Telemetry"

Problem Description

A high reliability telemetry system for electroencephalograms is required.

Background

The electroencephalogram (EEG) is a method of recording graphically the electrical activity of the brain by means of electrodes attached to the scalp. It is used for many applications such as diagnosis of epilepsy, trauma, tumors, and degeneration of the brain. The signal consists of oscillations from 1 hertz to 60 hertz with a voltage range between 20 to 200 microvolts.

The researcher is studying the effect of amphetamines on animals both in a sleeping and waking state. The animals of interest, cats and monkeys, are sufficiently mobile so that wires attached to the animal from the recording device significantly hamper the animal's activity. An EEG telemetry system small enough to be mounted on the experimental animals for periods up to two weeks is required.

Requirements and Constraints

The high reliability transmitter should be small enough (20 grams) to be mounted on a cat as well as a monkey. The transmitter will be mounted external to the body so that batteries can be changed during the two-week operation period. Transmission distance will be less than 50 feet.

Problem Originator

E. H. Ellinwood, M.D.
Duke University Medical Center

For more information contact

F. Thomas Wooten, Ph.D.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

A computer search of the NASA literature, #1749, "Biocompatible Plastics," has been delivered to the researcher.

Problem Statement

Prepared for

DU-56
June 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Material for Hip Joint Prosthesis"

Problem Description

An improved bonding method of material is required for joining bone to metal and plastic materials.

Background

A major crippling disease in this country is arthritis which is a disease of the joints. In severe cases the bone deteriorates to such a degree that joint replacement is necessary to alleviate pain and joint stiffness. One common joint requiring replacement is the hip.

Hip joint replacement or prosthesis is accomplished by replacing the ball and socket of the bone with a ball and socket of some appropriate material. Although the ball and socket can be of different materials, they are usually made of the same material. The most commonly used material is Vitallium which is a chrome-cobalt alloy. Unfortunately, Vitallium has two disadvantages--excessive wear and friction. The excessive wear causes a poor fit of ball and socket and the excessive friction promotes loosening of the prosthesis in the bone. Once the prosthesis becomes loose, pain and joint stiffness return. With existing materials, this can occur within one year but a lifetime of at least ten years is desired.

New materials for hip joint prosthesis are required with lower friction and wear than the presently used Vitallium.

Requirements and Constraints

The hip joint material must have low friction and low wear at pressures of 500 psi compression. It must be compatible with the body and be capable of being bonded to the bone. The ball and socket can be of dissimilar materials if both materials meet the other requirements.

Problem Originator

Donald E. McCollum, M.D.
Duke University Medical Center

For more information contact

F. Thomas Wooten, Ph.D.
Research Triangle Institute,
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

This problem is reported as a transfer in Section 2 of this report.

Problem Statement

Prepared for

DU-57
July 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Measurement Techniques for Isethionic Acid"

Problem Description

A technique is required for measuring isethionic acid (hydroxyethyl sulfonic acid) in animal tissue.

Background

In an effort to reduce heart disease in this country, careful study of the physiology of heart muscle is being conducted. The methods of studying heart muscle vary from considering the heart as a unit to considering individual heart cells. The latter case, cellular physiology, reveals much valuable information about the response of heart muscle to varying stimuli.

Each cell consists of a nucleus, which controls the cellular activities, surrounded by cytoplasm which contains the various components necessary for the tasks the cells perform. The cell is bounded at its outer limits by a membrane through which materials entering and leaving the cell must pass. One of the compounds which affects the passage of materials through this membrane is isethionic acid. By this process, isethionic acid is believed to regulate the excitability of cardiac tissue.

Isethionic acid also is believed to exist in nerve cells of some animals. Because of the low concentration of isethionic acid and the lack of measurement techniques for this compound, the exact role of the compound in biological systems is not well understood.

Requirements and Constraints

Analytical techniques for measuring isethionic acid concentrations in biological systems are required. The biological material does not have to be living so that processing of the material can occur. The exact concentration of isethionic acid is not known but is estimated to be quite low.

Problem Originator

Rubin Bressler, M.D.
Duke University Medical Center

For more information contact

F. Thomas Wooten, Ph.D.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

A computer search of the NASA data bank, #1766, "Measurement Technique for Isethionic Acid," has been delivered to the researcher.

Problem Statement

Prepared for

DU-58
July 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Urine Disposal System"

Problem Description

A portable system is required for human urine disposal.

Background

The kidneys produce about 1.5 liters of urine per day and continually discharge urine to the bladder for storage and subsequent discharge. The bladder can store up to 500 milliliters although it is normally emptied at around 200 milliliters. Victims of congenital defects, neurogenic bladder diseases, strokes, and multiple sclerosis, as well as war and automobile accident casualties, frequently experience bladder and urethral malfunctions. These malfunctions destroy the ability of the bladder to store urine.

Conventional methods for handling this problem are very crude and consist of collecting the urine in a bag for later disposal. The bags leak and are a source of odors. A better method of disposing of the urine is required.

Requirements and Constraints

A portable system of disposing of the urine is required. Since some types of urinary malfunctions allow partial urine storage in the bladder, the disposal system should be capable of handling an average daily volume of 1.5 liters. The system should be capable of disposing of the water in the urine leaving only the solid particles, although a system which solved the odor problem without water disposal would be of interest.

Problem Originator

Donald E. McCollum, M.D.
Duke University Medical Center

For more information contact

F. Thomas Wooten, Ph.D.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

A computer search of the NASA data bank is being performed.

Problem Statement

Prepared for

IRM-10
July 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Methods of Measuring Calcium"

Problem Description

The researcher is interested in the various methods that have been developed to measure calcium in body fluids and solids.

Background

The researcher is a biochemical pharmacologist. He is participating in a program which is directed to finding the cause of spinal defects in humans. The study will involve determination of calcium and phosphate metabolism, and one of the primary measurements which must be made is to assay the amount of calcium in body fluids and solids. The researcher is aware of some of the methods of measuring calcium including atomic absorption and polarographic and calorimetric techniques. Information on all the various methods of measuring calcium in body fluids and solids that have been tested and proven is desired. Sufficient information on these measurement techniques is desired to permit an evaluation of the techniques. With this information the technique most appropriate for use in his research program can be selected.

Requirements and Constraints

None.

Problem Originator

Dr. N. Eric Naftchi
Institute of Rehabilitation Medicine
New York, New York

For further information contact

Mr. Ernest Harrison, Jr.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

Computer search of NASA literature has been completed, and search has been delivered to the researcher.

Problem Statement

Prepared for

IRM-14
July 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Motion-Force Amplifier"

Problem Description

A motion-force amplifier which will permit restoration of arm and hand function to paralyzed patients is needed.

Background

A motion-force amplifier has been designed for use with wheelchair patients. The unit is an electrically driven device controlled by a small joy stick. It is assumed that the patient is able to move one extremity to all points within a 3-inch radius with minimal force. By moving the joy stick left, right, and back and forth, or in combinations thereof, it is possible to control, by means of a cabling and drive system, a mechanical exoskeleton which is fitted to the patient's other arm. Four distinct and spearate motions can be accomplished: (1) the entire arm can be rotated at the shoulder joint, (2) the elbow can be flexed, (3) the wrist can be rotated, and (4) the hand can be opened and closed in a manner to permit opposition of the thumb and forefinger. The force obtained with this unit is adequate, and the range of motion is adequate in selected directions.

The present unit is a single-speed system and causes the operator significant difficulty. The motions are jerky, sometimes too fast for certain tasks, and sometimes too slow for other tasks. The present unit is reversible. If a given motor performing one of the motions of the arm is energized in the forward motor direction by displacing the control stick, reversal of the motor direction, and hence reversal of the direction of motion of the controlled arm, is accomplished by displacing the control stick to its maximum excursion. This disengages the forward switch and engages the reverse switch. Obviously, this is a difficult control system to operate without error.

Another shortcoming is that the position of his arm can only be determined by the operator using "visual cueing." In essence, he can determine the position of his arm only by visually observing it.

Requirements and Constraints

The following improvements in the motion-force amplifier are desired:

(1) A simple proportional speed control with which the speed of movement of the arm is proportional to the displacement of the control mechanism.

(2) A means of achieving bi-directional actuation of the control motors that is easier to operate and less likely to cause operator error.

(3) A method of position feedback to the operator so he can "sense" the position of the controlled arm without constant visual tracking.

Problem Originator

Mr. H. Richard Lehneis
Institute of Rehabilitation Medicine
New York, New York

For more information contact

Mr. Ernest Harrison, Jr.
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P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

Problem identification phase has been completed.

Problem Statement

Prepared for

IRM-15
July 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Effects of Environmental Extremes on Skeletal Calcium"

Problem Description

The researcher is interested in effects of environmental extremes on skeletal calcium which may have been observed in NASA's experimental programs.

Background

The researcher is conducting basic research on spina bifidae. Spina bifidae is a congenital defect in the closure of the spinal canal. Its causes are not known. Recent surgical procedures and hyperbaric oxygen therapy have prolonged the life of patients, but they still require an enormous amount of rehabilitation, time, and facilities. Dr. Kamrin is seeking information on body calcium disturbances, their causes and effects, which might be correlated with spinal defects such as spina bifidae. Body calcium disturbances that have been attributed to weightlessness have been reported in astronauts. Dr. Kamrin has requested information on the effects of weightlessness and other environmental extremes on skeletal calcium.

Problem Originator

Dr. Benjamin J. Kamrin
Institute of Rehabilitation Medicine
New York, New York

For further information contact

Mr. Ernest Harrison, Jr.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

Computer search of NASA literature has been conducted. Search has been delivered to researcher, and documents have been ordered. The researcher has been out of the United States during the summer. This problem will become active again when the researcher is available.

Problem Statement

Prepared for

IRM-16
July 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"A Means of Measuring Displacement"

Problem Description

A small transducer to measure displacement of a finger is required.

Background

The researcher needs a transducer which can be used to indicate the displacement as a function of time of the fingers of myotonic people. One characteristic of myotonic people is that they have a weak hand grip in which the muscle contracts at a normal speed, but the grip is not easily relaxed. That is, the muscle relaxation takes place over a prolonged period of time, so that when a myotonic person grasps an object, it takes him a relatively long time to release the object.

Presently, these people are observed as they grasp and release an object. The observer makes a judgment of whether the release is normal, slow, or very slow. It is desired to quantify the time rate of relaxation of the muscles involved. To permit this quantification, the researcher wishes to record the time rate of movement of a finger in the plane defined by the motion of the finger in moving from a clenched fist to a fully extended position. This information would be used to set up a diagnostic test to detect myotonia in people.

Requirements and Constraints

The finger is displaced along a curved path (from 6 to 8 inches in length) in the plane defined by the motion of the finger in moving from a clenched fist to a fully extended position. Measurement of the displacement to accuracies of $\pm$ 5 percent would be acceptable. The maximum time required for the finger to prescribe this path is approximately one minute and the minimum time is less than one-fourth second. If the transducer is attached to the finger, the force required to move the transducer (counter force exerted on the finger) must be less than one ounce. Noncontact sensing would be desirable. However, because this is a clinical application, simplicity and economy are prime requirements which will be used in evaluation of various approaches to the solution of this problem.

Problem Originator

Dr. Arthur Eberstein
Institute of Rehabilitation Medicine
New York, New York

For more information contact

Mr. Ernest Harrison, Jr.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

A computer search of the NASA literature has been completed and delivered to the researcher for his evaluation.

Problem Statement

Prepared for

IRM-17
July 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"A Small, Simple Force Transducer"

Problem Description

The researcher desires a small, simple force transducer.

Background

The researcher needs a transducer which can be used to indicate the amount of force that can be exerted by the fingers of myotonic persons when the hand is clenched into a fist. Persons with myotonia (tonic muscular spasm) exhibit very slow muscle relaxation rates. In addition, the force with which they can close the hand is diminished. In order to measure the muscle impairment resulting from myotonia, the researcher desires to measure the maximum force that can be attained by a myotonic person during clenching of the hand.

Requirements and Constraints

The transducer should be small enough to measure the force exerted by individual fingers and should be sufficiently thin so that it does not interfere with closing the hand to form a fist. A ¼-inch by ¼-inch unit with a thickness of 1/16 inch would be acceptable. Accuracy should be within 0.5 ounce, and the measurement range should be from 0.5 ounce to 5 pounds.

Problem Originator

Dr. Arthur Eberstein
Institute of Rehabilitation Medicine
New York, New York

For more information contact

Mr. Ernest Harrison, Jr.
Research Triangle Institute
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North Carolina 27709

Status

Problem identification phase has been completed.

Problem Statement

Prepared for

IRM-20
August 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Prevention of Orthostatic Hypotension"

Problem Description

A G- or pressure suit is requested to determine if its use will permit a patient suffering from orthostatic hypotension to stand erect without loss of consciousness.

Background

Researchers at Goldwater Memorial Hospital of New York University Medical Center have encountered a patient suffering from orthostatic hypotension. The underlying cause is suspected to be neural damage. Complicating this condition is the fact that the patient has previously sustained a hip injury which resulted in the left hip being fused in extension. With the hip fused, the patient could only stand or lie down. The occurrence of orthostatic hypotension now prevents the patient from standing; consequently, the only position the patient can assume is a reclining one. All attempts to bring the patient to an erect position using a tilt table, elastic bandages, and abdominal binders have been unsuccessful. Prior to this operation, the patient was able to walk with forearm crutches. She has the power in all extremities to maintain herself in the erect position if she could maintain her blood pressure. Although this problem concerns only one specific patient, there are, no doubt, numerous other people who could benefit from a technique that would permit people with orthostatic hypotension to stand erect.

Requirements and Constraints

The researchers feel that a pressure suit for the waist down (one that essentially fits the legs) in which the degree of counter pressure can be controlled may be more effective in combatting the patient's difficulty than the measures already employed. The researchers are interested in the availability of a pressure suit that could be used in this application. This request has been made of the Biomedical Application Team because of the widespread work of NASA in development of G-suits and pressure suits for the aerospace program.

The dimensions of the patient are:

waist	40"
hips	44-1/2"
right lower extremity (hip joint to sole of foot)	36"
left lower extremity	36"
right thigh (maximum)	22"
left thigh (maximum)	26"
right ankle	7-3/4"
left ankle	8-1/2"
shoe size	7-1/2C

Problem Originator

Dr. August Alba
Dr. Frieda S. Trainor
Goldwater Memorial Hospital
New York University Medical Center

For further information contact

Mr. Ernest Harrison, Jr.
Research Triangle Institute
P.O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

Mr. John Samos, Technology Utilization Officer at Langley Research Center, has obtained a G-suit on a loan basis to permit the researcher to evaluate the effectiveness of the suit in this application. The suit has been delivered to the researcher for tests.

Problem Statement

Prepared for

IRM-21

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"An Improved Splinting and Cast Material"

Problem Description

A lightweight, high-strength, easily fabricated splinting and cast material is desired.

Background

Large numbers of patients at the Institute of Rehabilitation Medicine require casts, custom-fitted splints, and orthotic devices. Much of the fitting requires shaping to complex contours. Perhaps the most widely used and most successful material is plaster of paris. It is quite time-consuming to construct these items from plaster. The finished items are relatively heavy and difficult to keep clean. Also, the materials are not reusable. On the positive side, plaster of paris is inexpensive, and its strength and resistance to the mechanical shock and the temperatures normally encountered are generally adequate. A lightweight, inexpensive casting material which can be easily fabricated into intricate shapes is desired. Various plastic materials have been marketed as cast and splint materials, but none tested to date have all the desired properties. Most are expensive, difficult to form, and unable to withstand normally encountered direct sunlight and heat.

Requirements and Constraints

When made into a cast or splint, the material must have sufficient strength and shock resistance to properly support the patient and to withstand the impact forces that might normally be encountered. It should be able to withstand direct sunlight, boiling water, and household chemicals.

Problem Originator

Mr. H. Richard Lehneis
Institute of Rehabilitation Medicine
New York, New York

For futher information contact

Mr. Ernest Harrison, Jr.
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P. O. Box 12194
Research Triangle Park,
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Status

Problem identification phase has been completed.

Problem Statement

Prepared for

IRM-22
August 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"A Means of Tracking Eye Movements While Viewing Printed Matter, Geometric Forms, and Pictures."

Problem Description

A means of determining continuously the movements of both eyes of hemiplegic (stroke) patients is desired. This essentially would consist of tracking the eye movements with time as the patient views the desired subject matter.

Background

Visual scanning difficulties in one side of the visual field are often encountered in the hemiplegic patient. (These scanning difficulties interfere in the processing of visual information. They prevent the hemiplegic from singling out pertinent cues that are involved in visual-perception tasks.) Some tend to ignore visual stimuli located on their impaired side; others render false information on the impaired side and, as a result, spoil the information on their intact side; while still others compensate by turning their heads. These difficulties affect his cognitive functioning and have consequences for activities in his daily life, such as reading, dressing, and manipulation of his wheelchair. There is also a relationship between scanning difficulties and accidents in the hemiplegic population.

Requirements and Constraints

It is desired to explore the movements of the eye while the patient is viewing printed matter, geometric forms, and pictures. This information will permit comparison of hemiplegic patients with normals and hopefully will permit characterization of hemiplegic eye movements. The apparatus or measuring technique should permit collection of the following information when the patient is reading a newspaper or looking at a picture.

1. Is scanning initiated on the left or right side?
2. Is the upper or lower half preferred?
3. Does the eye perform horizontal or vertical excursions with greater frequency?

4. Is the excursion distance greater in the horizontal or vertical plane?
5. Is the number of fixations greater on the left or right side?

An apparatus that will provide a graphic picture of the hemiplegic's eye movements as a function of time will aid in analyzing the specific visual-perceptual difficulties of each patient. It will also assist in devising appropriate individual programs of retraining, suitable for each hemiplegic's need.

Problem Originator

Dr. Leonard Diller
Institute of Rehabilitation Medicine
New York University Medical Center

For further information contact

Mr. Ernest Harrison, Jr.
Research Engineer
P. O. Box 12194
Research Triangle Park
North Carolina 27709

Status

An oculometer unit developed at NASA Electronics Research Center has been identified as a potential solution to this problem. Detailed performance characteristics plus equipment availability and cost information has been requested in order to permit evaluation of the applicability of the unit to the problem requirements.

Problem Statement

Prepared for

RTI/NCI-1
August 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Noise Reduction in Laminar Flow Rooms"

Problem Description

Noise abatement methods and low noise fans are required for laminar flow rooms used for patient isolation.

Background

The National Cancer Institute is conducting a vigorous program to find the causes and cure for cancer, a major cause of death in this country. One of the approaches used is chemotherapy, or the use of drugs to cause remission of existing cancers. Patients requiring this treatment are usually weak and more susceptible to other diseases than normal patients. A sterile environment will help to combat this problem as well as increasing the patient tolerance to antitumor drugs with regard to incidence of infection. A sterile environment can be produced by a laminar flow room which is equipped with sterilizing agents in the filter system.

The existing laminar flow rooms have been designed to be installed inside standard hospital rooms; this allows maximum flexibility in the use of these rooms. This design, however, requires that the blower fans be inside the patient's room, which creates a noise problem. A heating and air conditioning consulting engineering firm has added conventional noise abatement procedures such as foam padding in ducts, a discharge muffler, and vibration isolators on the motors. However, even with these additions, the existing noise level must be reduced.

Requirements and Constraints

Noise abatement procedures are desired which will reduce the noise level from the existing Noise Criterion 50 to near Noise Criterion 30. Noise Criterion 30 is defined as approximately 50 db at 100 Hz and 26 db at 10,000 Hz. The air velocity output varies between 30 and 90 ft/min. A centrifugal fan is used.

Problem Originator

William Z. Penland
National Cancer Institute

For further information contact

F. Thomas Wooten, Ph.D.
Research Triangle Institute
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North Carolina 27709

Status

A computer search, #1811, "Noise Reduction of Fans," of the aerospace data bank has been delivered to the researcher.

Problem Statement

Prepared for

VU-1
June 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Improved Material for Percutaneous Tubes for Blood Dialysis"

Problem Description

An improved material is required for percutaneous tubes for blood dialysis.

Background

The kidneys are organs that remove impurities from the blood. The entire human blood supply is filtered through the kidneys about 20 times each day. It is estimated that about 50,000 Americans die from kidney disease each year. If serious kidney disease occurs, artificial removal of blood impurities (dialysis) is required using the artificial kidney through which the blood supply must be circulated.

A patient requiring dialysis must be connected to the artificial kidney twice a week. To facilitate this frequent connection, small tubes (cannulas) are connected to both a vein and an artery of the arm. These tubes are connected by a shunt which allows blood to flow when the patient is not connected to the artificial kidney. The shunt is removed when the patient is attached to the artificial kidney.

A problem arises when a tube intersects the skin (percutaneous tube). This break in the skin is often the site of infections because of an improper seal between tube and skin. The tube is normally constructed of silastic but an improved material is required which will prevent this infection.

Requirements and Constraints

The tube material should be compatible with body tissue and must allow adequate sealing of the skin. The material also must not cause clotting of blood.

Problem Originator

H. Earl Ginn, M.D.
Vanderbilt University School of Medicine

For more information contact

F. Thomas Wooten, Ph.D.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

Dr. Ginn has been apprised of the work of Mr. Jim Benson of North American-Rockwell Corporation and Biocarbon Corporation regarding vitreous carbon. Dr. Ginn expressed an interest in obtaining several tubes for blood compatibility studies in dogs. Mr. Benson has agreed to fabricate the desired samples.

Problem Statement

Prepared for

WF-69
June 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Correlation Techniques"

Problem Description

Information is desired on the application of correlation techniques to the data signals commonly encountered in cardiovascular research.

Background

The researcher has a general interest in the computer processing and enhancement of cardiovascular data. A recent article in the open literature has indicated that correlation techniques can be applied to data obtained from a two-point velocity probe in a fluid stream so as to yield information on turbulence and diffusion in the flowing stream. After reading of these techniques the researcher feels that they have potential value in a number of biomedical applications directly concerned with his research program in cardiovascular physiology. For example, in determining cardiac output by indicator dilution methods, it is important that the flow profile be laminar (not turbulent). A means of detecting the onset of turbulent flow would be of value in this application. A number of other potential applications can easily be listed. The researcher wishes to identify means of applying these techniques in the field of cardiovascular physiology.

Problem Originator

Dr. G. L. Malindzak, Jr.
Bowman Gray School of Medicine
Wake Forest University

For more information contact

Mr. Ernest Harrison, Jr.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

Mr. James Richards, NASA TU Division, has identified a researcher at NASA George C. Marshall Space Flight Center who is interested in applying correlation techniques to the biomedical field. Methods are being explored to bring about a useful interaction between Dr. Malindzak and the researcher at Marshall Space Flight Center.

Problem Statement

Prepared for

WF-70
June 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Underwater Telemetry"

Problem Description

A means of telemetering EEG, heart rate, respiration,and temperature from free-swimming porpoises in large tanks.

Background

The porpoise has a remarkable physiology, particularly as related to his ability to make deep dives in the ocean and rapidly return to the surface. The adaptation of the porpoise's physiology to accomplish this feat is of great interest. The auditory physiology of the porpoise is very highly developed. The chemistry of sleep in the porpoise and how it relates to his physiology during deep diving is also of interest. The researcher is conducting a research project to obtain information on the free-ranging porpoise that will permit a better understanding of the unusual physiology of the porpoise. Specifically, he would like to instrument free-swimming animals in a 40-foot tank so that the following data can be received and recorded. In order of importance, they are: (1) EEG, (2) heart rate, (3) respiration rate, and (4) temperature.

Requirements and Constraints

A telemetry unit which can transmit all four signals is desired. It would be most desirable if the telemetry transmitter signal from the porpoise could be received directly outside the tank. The researcher is aware of underwater systems (using sonic techniques), but he also desires information on telemetry techniques as well. The least desirable approach would be to attach a line and an airborne balloon to the porpoise with the transmitting antenna thus being kept above the water's surface. This approach would be acceptable only if significant reductions in equipment complexity and cost could be gained thereby.

The porpoise is a large animal and can be equipped with a harness to which equipment can be secured. Consequently, the size and weight requirements are not at all severe. The unit must, of course, be capable of operation in sea water.

Problem Originator

Dr. James G. McCormick
Bowman Gray School of Medicine
Wake Forest University

For more information contact

Mr. Ernest Harrison, Jr.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

Computer search of the NASA literature "Underwater Telemetry," Bibliography #M3P has been delivered to the researcher. He has reviewed the search and selected documents. The documents have been delivered for his evaluation.

Problem Statement

Prepared for

WF-72
August 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Automatic Control System for a Tilt Bed"

Problem Description

Information is desired on automatic control circuitry which has been developed to change the position of a tilt bed or tilt table in response to the variation of a physiological parameter.

Background

The researcher is interested in applying a tilt bed to the control of blood pressure in patients in hospitals. The tilt bed would vary its elevation angle with respect to the horizontal in response to blood pressure variations in the patient. Blood pressure is sensed every 10 minutes by an automatic blood pressure measuring instrument employing an inflatable finger cuff. When the patient's blood pressure is normal ($\approx$120 mm Hg) with the bed horizontal, it would remain horizontal. If the pressure increased by +20 mm Hg, the control system would be required to energize the bed so as to raise the head of the bed 15^{o} in elevation. After a 10-minute wait, the blood pressure instrument would sample the blood pressure again. If the pressure were then within $\pm$ 19mm Hg of normal, the bed would remain in the 15^{o} raised position. If the pressure is still 140 mm or greater, the bed would be raised another 15^{o}. This would continue until either the blood pressure returns to normal or the maximum elevation angle of the bed is reached. This maximum elevation angle is 45^{o}. At any of these positions (0^{o}, 15^{o}, 30^{o}, 45^{o}) the control system should lower the bed 15^{o} if the blood pressure drops 20 mm Hg less than normal (120 mm Hg). The maximum depression in elevation angle of the bed is -15^{o}.

Operating in this manner, the control circuitry would act to place the patient in the proper position to correct for deviations in blood pressure of $\pm$ 20 mm Hg from normal.

Requirements and Constraints

The output of the blood pressure measuring unit is a voltage varying from zero to one volt. One millimeter of Hg pressure corresponds to approximately 3 millivolts output. Thus, normal blood pressure would approximately correspond to a voltage output of 360 millivolts. When a blood pressure reading is taken and the voltage has risen to 420 millivolts (140 mm Hg pressure),the control

circuity should apply 115 volts AC to the "raise" windings of the tilt bed motor until the bed is raised 15^{o}. If, when a blood pressure reading is taken, the voltage has fallen to 300 millivolts (100 mm Hg),the control circuity should apply 115 volts AC to the "lower" windings of the tilt bed motor until the bed is lowered 15^{o}. An interlock system is required to prevent the bed from exceeding -15 or $+45^{o}$ in tilt angle.

The researcher is seeking an existing design. Engineering, redesign, or significant modification of existing technology is not desired. Because of the extensive work by NASA with tilt tables, it was felt that there was a reasonable probability that NASA had designed a control circuit to vary tilt table elevation angle in response to a physiological variable as required in this problem.

Problem Originator

Dr. James F. Toole
Bowman Gray School of Medicine

For more information contact

Ernest Harrison, Jr.
Research Triangle Institute
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Research Triangle Park,
North Carolina 27709

Status

A computer search of the aerospace literature "Tilt Tables," #1795, was forwarded to the researcher for evaluation.

Problem Statement

Prepared for

WF-75
August 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

by

Research Triangle Institute

"Measurement of Intracellular Pressure"

Problem Description

A pressure transducer small enough to measure pressure within individual cells.

Background

The researcher, a cell physiologist, wishes to obtain a pressure transducer small enough to measure pressure in individual cells. Presently, a glass tubing (cannula) drawn to an extremely small bore at the tip is inserted into the cell. A small, solid state pressure transducer is attached to the other end of the glass tube. Water is used as the coupling medium to permit measurement of internal pressure exterior to the cell. The mass of the coupling medium in the cannula reduces the frequency response to approximately 200 hertz. In order to measure the high frequency pressure transients that are thought to occur in cells, the researcher wishes to obtain a frequency response of 5-10 kilohertz. Elimination of the cannula and direct insertion of a pressure transducer into the cell is one method of attaining a higher frequency response.

The cells in which the researcher desires to measure pressure have a maximum diameter of 150 microns. A means of measuring pressure within such cells is desired which does not attenuate the high frequency variations.

Requirements and Constraints

The measurement technique must have a frequency response of at least 5 kilohertz. The maximum pressure to be measured is 10 centimeters of water.

Problem Originator

Dr. Edward Lieberman
Bowman Gray School of Medicine

For more information contact

Ernest Harrison, Jr.
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Status

Problem identification complete.

4.0 PROBLEM STATUS SUMMARY

Problems which are being investigated by the RTI Biomedical Application Team are generally classified as active or closed. Active problems are further subdivided according to the progress or phase of the investigation. Problems are generally closed when either a technology transfer is accomplished or it is judged that further investigation is not likely to produce useful results in a reasonable time. Closed problems are coded according to specific reasons for such action. This section contains a summary and analysis of problems which were active at the end of this reporting period and problems which were closed during the reporting period.

4.1 Active Problems

4.1.1 Active Problem Categories

The term "active" means that the problem is still under consideration and that solutions are being sought either on a regular review or a continuing investigative basis. It is implicit in the following discussion that the problems are considered to have a sufficiently high probability of solution as to warrant further activities.

In the Active Problem Summary, Table 1, active problems are divided into the following six status categories:

A. Problem Definition

Problem definition includes the identification of specific technology-related problems through discussions with biomedical investigators and the preparation of functional discriptions of problems using nondisciplinary terminology.

B. Information Searching

Information relevant to a solution is being sought by computer and/or manual information searching.

C. Problem Abstract Dissemination

An information search has revealed no potential solutions, and a problem abstract is being circulated to individual scientists and engineers at NASA centers and contractor facilities to solicit suggestions.

D. Evaluation

Potentially useful information or technology has been identified and is being evaluated by the team and/or the problem originator.

E. Potential Transfer

Information or technology has been evaluated and found to be of potential value but has not been applied.

F. Follow-up Activity

A technology transfer has been accomplished, but further activity (i.e., documentation, obtaining experimental validation of utility, continuing modification, etc.) is required.

4.1.2 Active Problem Summary Data

The status of all active problems is presented in Table 1. The information included in this table gives problem number and title, date accepted, and a status code for the six categories defined in the preceding section.

Table 1. Active Problem Summary

Problem Number	Problem Title	Status	Date Accepted
DU-31	Catheter-Mounted Pressure Transducer.	B	12-67
DU-45	Low-Velocity Anemometry.	D	2-69
DU-46	Electrode Material for Pacemakers.	D	3-69
DU-47	Urethral Pressure Transducer.	B	4-69
DU-48	Urine Flowmeter.	D	4-69
DU-50	Deep Diving Breathing Systems.	D	4-69
DU-53	EKG Telemetry.	D	6-69
DU-56	Material for Hip Joint Prosthesis.	F	6-69
DU-58	Urine Disposal System	D	7-69
IRM-1	Determination of Brace Socket Pressure.	B	4-69
IRM-2	A Body Power Energy Storage System.	B	4-69
IRM-4	An Improved Material for Construction of Self-Adjusting Braces.	B	4-69
IRM-5	An Improved Flexible Lead Wire for Implantable Devices.	B	4-69
IRM-6	An Improved Encapsulant for Implantable Devices.	B	4-69
IRM-7	A Material for Use in Direct Contact with Blood Which Exhibits Reduced Clotting Characteristics.	B	4-69
IRM-8	Low Temperature Lubricant for Microtomes.	D	5-69
IRM-9	Information on Normal Blood Pressure and Blood Flow in Large Populations.	B	5-69
IRM-10	Methods of Measuring Calcium.	B	7-69
IRM-14	Motion Force Amplifier.	B	7-69
IRM-15	Effects of Environmental Extremes on Skeletal Calcium.	B	7-69
IRM-16	A Means of Measuring Displacement.	B	7-69

Table 1. (continued) Active Problem Summary

Problem Number	Problem Title	Status	Date Accepted
IRM-17	A Small Simple Force Transducer	B	7-69
IRM-20	Prevention of Orthostatic Hypotension	E	8-69
IRM-21	An Improved Splinting and Cast Material	D	7-69
IRM-22	A Means of Tracking Eye Movements While Viewing Printed Matter, Geometric Forms, & Pictures.	B	8-69
MISC-2	Fast X-ray for Field Hospital.	D	2-69
NCI-1	Noise Reduction in Laminar Flow Rooms	B	8-69
NCSU-6	Analysis Techniques for EEG Data	D	3-69
NCSU-7	Telemetry System for EEG Data	D	3-69
UNC-38	Electromyography as an Aid to Hand Rehabilitation	F	2-68
UNC-42	A Means to Collect Exhaled Breath	B	6-68
UNC-47	An Improved Splinting Material	D	1-69
UNC-48	An Improved EMG Electrode for Hand Therapy	F	2-69
UNC-49	A Manipulator for Therapy in Abductor Transfer Cases	F	2-69
UNC-50	General Purpose, Indicating, Pressure Sensitive Muscle Trainer	B	2-69
UNC-51	An Improved Electrode for Electro-Diagnosis.	F	4-69
UNC-53	Design Information Relating to Cardiotachometer Circuitry.	F	5-69
UNCD-1	A Method of Producing Silver-Copper and Silver-Tin Alloys in Powder Form with Spherical Shape and with Particle Sizes in the Range of 2 to 4 and 6 to 10 Microns	B	4-67
UNCD-3	A Means to Obtain Rapidly a Pictorial Representation of the Temperature Distribution of the Interior of the Oral Cavity in Humans.	B	4-67
UNCD-5	An Improved and Reliable Electric Tooth Pulp Tester	B	5-67
UNCD-6	A Small Sensor to Measure Viability of Human Teeth	B	5-67
UNCD-15	A Device to Measure Looseness of Teeth	B	5-68

Table 1. (continued) Active Problem Summary

Problem Number	Problem Title	Status	Date Accepted
UNCD-16	A Sensor to Measure Stress Distribution in Bone as A Result of Applied Force	B	5-68
UNCD-17	A Method of Measuring Tongue-Lip Pressures on the Teeth	B	5-68
UNCD-18	Method of Determining if Tooth Roots are Attached to the Jaw Bone Structure	B	5-68
UNCD-19	A Means of Applying an Electric Field to the Root of the Tooth in Order to Stimulate Bone Resorption.	B	5-68
UNCD-20	A Means of Applying Force to Teeth so that Orthodontic Correction in the Position of the Teeth Can be Achieved.	B	5-68
UNCD-21	A Method of Measuring the Relative Displacement of Teeth With Respect to Some Fixed Point.	B	5-68
UNCD-22	A Method of Measuring the Force Applied to a Tooth by an Orthodontic Structure	B	5-68
UNCD-23	An Improved Metal with Low Corrosion Rate and High Elastic Modulus for Orthodontic Fixtures.	B	5-68
UNCD-24	Adhesive for Attaching Brackets to Teeth	B	5-68
UNCD-25	A Miniaturized Electrical System to Shock the Tongue of Patients When it is Pressed Against the Rear of their Teeth.	B	5-68
UNCD-26	A Method of Measuring the Height of Bone with Respect to the Teeth in the Jawbone Structure	B	5-68
UNCD-27	A Method of Maintaining a Thin Tissure Section in Exact Position with Respect to an X-ray Film Plate for an Indefinite Period Even During Development of the Film.	B	5-68
VU-1	Improved Material for Percutaneous Tubes for Blood Dialysis		6-69
WF-3	Prosthetic Valve for Urinary Tract	F	8-66
WF-13	Radiation Detector for In Vivo Measurement of Absorbed Dose	F	10-66
WF-24	Respirator Control System that Adjusts Both Volume and Rate as Well as Other Parameters According to Body Needs Determined by Monitoring Continuously the Partial Pressures of Gases in the Blood Stream.	B	5-67

Table 1. (continued) Active Problem Summary

Problem Number	Problem Title	Status	Date Accepted
WF-28	A Method of Mixing Indicator with Blood as it is Injected into Veins and Arteries and a Method of Mixing Again Just Before the Sampling Site	B	9-67
WF-29	An Electrode for Measuring Hydorgen Ion Concentration and CO_2 Partial Pressure in the Blood is Needed	B	12-67
WF-30	An Improved Blood Vessel Constrictor	F	12-67
WF-31	A Servo-Controlled System to Measure pO_2 and pCO_2 in Expired Gases and to Control the Operation of Respirators	B	12-67
WF-32	Oxygen Toxicity Effects	D	12-67
WF-33	Biotelemetry Units	D	12-67
WF-36	Implantable Pressure Sensor and Telemetry Unit for Measurement of Fluid Pressure in the Cranial Cavity.	D	1-68
WF-37	An Implantable Valve Which Can be Remotely Opened and Closed from Outside the Body	F	1-68
WF-38	An Inexpensive Sterile Fabric for Sheets, Operating Room Gowns, Tissue Transfer, etc.	B	1-68
WF-40	Localization of Blood Pools in Various Cavities of the Body	D	2-68
WF-41	Low Cost, Swallowable, Temperature-Sensing Telemetry Capsule	D	2-68
WF-42	Ventilators for Small Animals	B	2-68
WF-44	A Means of Reducing Dose Rate While Taking X-ray Cineradiographs	D	2-68
WF-46	An Artificial Hand With Touch and Prehension Pressure Feedback to the Human Operator	B	3-68
WF-47	Information on Techniques and Advances in Thermography	D	3-68
WF-48	Information on Cardiovasculary Systems	D	3-68
WF-50	Application of Time-Series Analysis to Computer Processing of Biomedical Data	F	4-68
WF-52	Methods of Triggering from a Fixed Reference Point on the EKG Waveform	F	5-68
WF-53	Means of Obtaining the Velocity Spectrum of Blood Flowing in Arteries & Veins	B	5-68

Table 1. (continued) Active Problem Summary

Problem Number	Problem Title	Status	Date Accepted
WF-54	An Improved Sensing System for Indicator Dilution Studies	F	6-68
WF-55	A Simple Means of Sensing Whether Respirator is Actually Performing the Respiratory Function on Humans	F	6-68
WF-56	An Improved Fluid Pressure Calibration System	B&D	6-68
WF-59	Noninvasive Means of Detecting the "Bends" in Humans During and Following Decompression	D	8-68
WF-61	An Improved Method of Determining Volume Elasticity of Blood Vessels	B	9-68
WF-62	An Extremely Thin Pressure Transducer to Measure the Pressure Exerted on Tissue by Support-Type Hosiery	D	11-68
WF-63	A Low Cost, Swallowable, pH Sensing Telemetering Capsule	F	12-68
WF-64	Improved Method of Making Volume Plethysmographic Measurements Related to Volume Changes in Tissue Caused by Influx and Efflux of Blood During the Cardiac Cycle	B	1-69
WF-65	Function Multipliers to Compute Derivable Physiological Parameters	B	3-69
WF-66	An Analog Computer with Interchangeable Problem Boards	B	3-69
WF-67	A Filter to Separate Physiologic Data Occurring at Nominal Heart Rates from Lower Frequency Data	B	3-69
WF-69	Correlation Techniques	D	6-69
WF-70	Underwater Telemetry	B	6-69
WF-72	Automatic Control System for a Tilt Bed	B	8-69
WF-75	Measurement of Intracellular Pressure	B	8-69

4.1.3 Active Problem Analysis

The status of presently active problems are further summarized in Table 2 as to the number of active problems in each category as well as the percentages of the total number in each category. These numbers are compared with the equivalent figures for the end of the immediately preceding quarter. Note that for the end of this quarter the total number of the various categories is 93, while the actual number of active problems is 92. This is because problem number WF-56 reasonably fits into two categories.

The comparison of the figures for the end of both quarters shows little change in the relative percentages of each category although the total number of problems has increased from 80 to 92. The major portion of the problems continue to be in the information searching stage which reflects the fact that the team devotes a considerable part of its effort in the summer months to information searching and to evaluation of search results as opposed to activities which require close contact with the researchers. Many of the researchers are away during the summer months and the team must schedule its activities to reflect this fact.

Table 2

Active Problem Summary Data

	June 14, 1969		September 14, 1969	
Category	No. of Problems	%	No. of Problems	%
A. Definition	0	0	0	0
B. Search	45	56.3	53	57
C. Abstract	1	1.2	0	0
D. Evaluation	19	23.8	24	25.8
E. Potential Transfer	2	2.4	1	1.1
F. Follow-up	13	16.3	15	16.1
Total	80	100.0	93	100.0

4.2 Closed Problems

4.2.1 Criteria for Closing Problems

A periodic review is conducted of all problems in order to eliminate those problems which are no longer considered to be active. Problems are closed when a technology transfer has been accomplished and also when it is judged that a solution cannot be found and/or applied in a reasonable time.

Reasons for closing the problems are divided into the following categories:

A --- Transfer accomplished.

B --- Researcher has no further interest in the problem.

C --- Researcher has found his own solution.

D --- As a result of personnel transfer in the medical institutions, the problem has either been closed or transferred to another institution along with the investigator and has been given a new number.

E --- No present or forseeable future NASA technology applicable.

H --- Satisfactory solution identified by team and verified by researcher but transfer cannot be completed by researcher for reasons of economy or lack of resources.

I --- Problem as originally stated was too broad or general.

J --- Problem is too difficult; i.e., the problem as given to the RTI Biomedical Application Team is presently the focus of large expenditures of money, research, and development effort making the likelihood of success by the Biomedical Application Team low.

K --- Problem priority too low. Factors involved are cost/benefit ratio, team resources available, researcher's resources, and enthusiasm.

These categories were evolved as a result of interaction between all three Biomedical Application Teams and members of the Biological Sciences Communication Project at George Washington University.

4.2.2 Summary of Closed Problems

Table 3 lists those problems which were closed during the reporting period of 15 June 1969 to 14 September 1969.

Table 3

Problems Closed During 15 June to 14 September 1969

Problem No.	Title	Category
DU-36	Cervical Cancer Diagnosis.	B
DU-40	Differential Pressure Transducer for Cardiac Catheter	A
DU-41	Electrode Vest for EKG Measurement	A
DU-49	Electromyography of the Ureter	E
DU-52	Binding Agents for Hip Joint Prosthesis	D
DU-57	Measurement Techniques for Isethionic Acid	E
IRM-3	An Improved Spiral Brace	C

5.0 OTHER ACTIVITIES OF THE BIOMEDICAL APPLICATION TEAM

5.1 Professional Meetings Attended

The International Conference on Medical and Biological Engineering and the Annual Conference on Engineering in Medicine and Biology is a joint conference of major significance and was held on July 20-25, 1969, in Chicago. The team was represented by Dr. F. T. Wooten, who reported the general conclusions drawn from the meeting to the NASA Technology Division and the other teams. One of the conclusions was that additional team efforts should be devoted to the field of surgery because of the needs and interest in engineering in that area. A second conclusion was that the area of patient monitoring was of great interest to all attendees which indicated an additional area for team concentration.

5.2 Application Engineering Activity

The real benefits of transferring aerospace technology into the field of medicine will not be realized unless the information and technology identified in this transfer program are actually used and applied in research and medical practice. This application in many cases requires significant applications engineering and, frequently, the creation of new commercial products. At the present time the applications engineering required in applying technology identified by the Biomedical Application Teams must be funded by the problem originator through his own research grants and contracts. The application team encourages the initiation of applications engineering when required and assists the researcher in obtaining the necessary engineering services.

In the solution of active problems, application engineering has been involved and in some cases is reported in the transfer summaries. Because these activities cover such a broad range, each effort is reported separately in the following:

(1) In problem DU-41, "Electrode Vest for EKG Measurements," the team discovered a requirement for an inflatable vest which would insure good contact between a large number of EKG electrodes and the human chest. The team identified an industrial source, Payne and Associates of Raleigh, N. C., which built a prototype of the vest for the researcher. This company is a NASA contractor which manufactures life vests for the

aerospace industry. The prototype vest was jointly designed by the researcher, the manufacturer, and the Biomedical Application Team.

(2) In problem UNC-53, "Design Information Relating to Cardiotachometer Circuitry," a requirement for design information on circuitry appropriate for use in a special cardiotachometer unit was identified. Information on the NASA-developed cardiac R-wave detector developed by Mr. Vernon D. Gebben of the Lewis Research Center was considered relevant to the problem and was furnished to the investigator. Information on the overall system configuration and system parameters was used by the researcher for reference and guidance purposes in selecting basic parameters and system approaches to the design of the required cardiotachometer. The engineering effort required to translate these system parameters into the final design configuration was accomplished by the researcher in his laboratory.

(3) As reported in Section 2 of this report, the team has identified a need for an implantable material in problem number VU-1, "Improved Material for Percutaneous Tubes for Blood Dialysis." The team identified carbon as a possible solution to this problem and contacted Mr. Jim Benson of North American-Rockwell Corporation as a source of the material. Mr. Benson and the physician, Dr. H. Earl Ginn, jointly designed a blood vessel implant for testing. Mr. Benson is at present fabricating this material.

5.3 Visits to NASA Centers

The valuable interface between medical research and aerospace research is improved by continued team interactions with the NASA field centers. Although numerous telephone contacts are made, the actual visit to the NASA field centers provides the best interaction possible. This section reports visits to the field centers.

Dr. R. M. Burger, Dr. J. N. Brown, and Dr. F. T. Wooten attended the Biomedical Application Team meeting at Lewis Research Center on August 6-7, 1969. Discussions were held with staff members at Lewis regarding problem number DU-46, "Electrode Materials for Pacemakers" and several useful suggestions were received. Dr. Wooten also contacted Mr. R. A. Johnson in regard to problem DU-56, which is reported as a transfer in this report.

On August 18, 1969, Dr. J. N. Brown and Dr. F. T. Wooten joined Mr. Jim Richards of NASA Headquarters at Langley Research Center for a visit

coordinated by Mr. John Samos, Technology Utilization Officer. A general discussion with about ten members of the Langley research staff was followed by individual discussions regarding specific research projects.

5.4 New User Institutions

Improvement in the quality of problems that the team accepts can be accomplished if the base of problems is expanded. This expansion can be done by carefully expanding the number of user institutions. The most recent user institution is the National Cancer Institute, Bethesda, Maryland. Initial discussions have been held with officials of the Chemotherapy Section and problem definition has begun. NCI officials have requested that the team discuss about 20 problems initially and that, from this list, a priority list of problems be derived jointly by the team and NCI. This new approach to problem selection should significantly enhance the quality of problems selected at this new institution.

The team has also made exploratory contacts at Tulane University, New Orleans, Louisiana, and the University of Virginia, Charlottesville, Virginia. Both schools appear to meet the necessary requirements for participation in the Biomedical Application Team program and personnel from both schools have expressed interest in the program.

6.0 CONCLUSIONS REGARDING THE TRANSFER PROCESS

The role of the consultant is a continuing matter of interest to the Biomedical Application Team and the importance of the consultant was underscored in a previous report*. In that report, it was documented that the percentage success in accomplishing transfers was significantly higher at Wake Forest University and Duke University where consultants were maintained than at the University of North Carolina where a consultant has not been available to the team on a continuing basis. The qualities which have been considered useful in the selection of a consultant are as follows:

(1) He must be enthusiastic about the Biomedical Application Team program.

(2) He must be cognizant of the overall research activities of the institution.

(3) His technical and research ability must be recognized and respected within the institution.

(4) A multidisciplinary background with some exposure to electronics, instrumentation, or computers is desirable.

(5) It is desirable that he be actively involved in research projects himself.

(6) He must be able to communicate with people.

Further thought and analysis has revealed that while all these characteristics would indeed be desirable, these criteria are difficult to apply in the selection of a good consultant.

Having already established that consultants are an extremely useful and necessary part of the program, it is important that criteria be developed to aid in the selection of a good consultant. It is in this area, i.e., usefulness as selection criteria, that the characteristics discussed in the final report fall short. A common circumstance concerning useful consultants is that, before they entered the Biomedical Application Team program, they were engaged in consultant-like activities. In each case, they were the

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*"Biomedical Applications of NASA Science & Technology," Final Report, 15 June 1968 - 14 June 1969, Contract No. NSR-34-004-056.

people within their respective organizations to whom the other members of the organization came for advice and consultation concerning technological developments and their application to individual research problems. In essence, our experience is that the person in an organization who is a problem-solver, the one whom colleagues seek out for advice in matters of research and technology, is a person who will make a good consultant. This type of individual will, as a result of his activities, evidence most of the qualities listed above; however, this single criterion appears easier to use in consultant selection. An additional advantage in using the problem-solver in an organization as consultant is the fact that he does not have to change his entire viewpoint. Rather, it is only necessary that his problem-solving activities be reoriented toward working with the Biomedical Application Team.

One further qualitative observation concerning the consultant is that a greater percentage of problems are identified by the Biomedical Application Team in the area of the consultant's research interest than the other fields at any given institution. The significance of this observation is that consultants should be selected who are themselves working in the research area that is the strength of the organization. Generally, each institution has at least one research area in which it is very strong; i.e., a large number of researchers are working in the area, the researchers are well-supported, and the organization is noted for its work in the particular area. The consultant should be selected from this group of people.

These two conclusions will be used in selecting consultants at new institutions in the future. The consultant is clearly a valuable element in an effective Biomedical Application Team and great care must be taken in his selection.

7.0 PLANS FOR NEXT QUARTER

In addition to the routine activities of the Biomedical Application Team as outlined in Section 1 of this report, the team will direct a significant effort during the next quarter toward the following specific tasks:

(1) Activities at the National Cancer Institute will be advanced to information searching and evaluation. The team plans to attack about three problems per month at NCI during the next quarter.

(2) The team plans to pursue the initial contacts at Tulane University and the University of Virginia and to determine if BATeam activities will prove fruitful at these schools.

(3) Discussions will be continued with officials of Duke University and the Regional Medical Program to determine the optimum method of utilizing aerospace technology to solve problems being encountered in the joint programs of these two organizations.

(4) The team believes that the capabilities of industry have not been sufficiently utilized in the Biomedical Application Team program. To overcome this obstacle, the team plans to launch a study to define the methods that will allow an effective interface with industry.